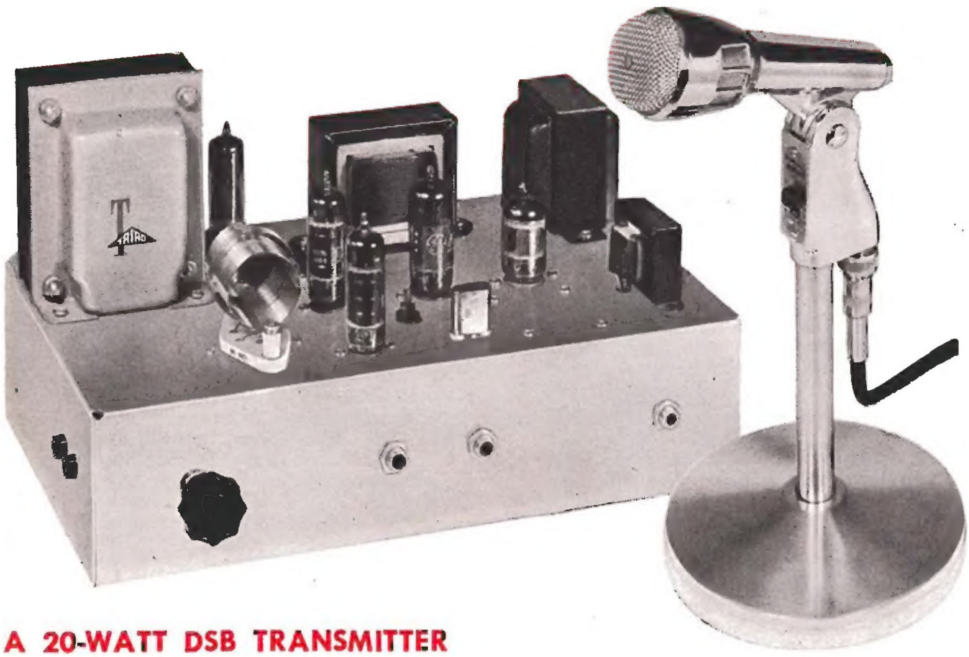
G-E Electronic TUBES

G-E HAM NEWS

GENERAL ELECTRIC

MARCH-APRIL, 1958 VOL. 13—NO. 2

DOUBLE SIDEBAND JUNIOR



A 20-WATT DSB TRANSMITTER FOR 3.8–4.0 MEGACYCLES

Get started on rapidly growing double sideband with this simple, junior-sized—but complete—transmitter designed by K2GZT (ex-WϕAHM). If this little rig looks familiar, you're one of literally thousands of radio amateurs who have examined it personally at ARRL conventions, and club meetings, during the past several months.

—Lighthouse Larry

CONTENTS

DOUBLE SIDEBAND JUNIOR

To say that radio amateurs have been expressing considerable interest in the double sideband, suppressed carrier communications system could easily be the understatement of the year. This has been obvious from the wealth of articles on the subject in recent electronics journals (see bibliography on page 8); also from the steady flow of requests for more information on double sideband in Lighthouse Larry's mail box.

This has resulted in the design of a simple, low-cost double sideband transmitter in which several desirable features have been included. The peak power input capability is about 20 watts, sufficient for putting a respectable signal directly into an antenna; or as a driver for a higher powered linear amplifier.

Before describing the transmitter, let's first examine double sideband as a communications system, which will reveal that the following benefits may be obtained:

1. Double sideband is a suppressed carrier system. This is another step toward eliminating hetrodyne interference—and the final amplifier power capability is not wasted on a carrier[1].
2. Since the output waveform is a replica of the modulating waveform, speech clipping may be employed to increase the average intelligence power.
3. A double sideband transmitter is quite inexpensive and simple compared to either amplitude modulated or single sideband equipment[2].
4. Modulation may be accomplished at the operating frequency.
5. Frequency diversity is inherent in the double sideband system. (The receiving operator has his choice of the more readable of two sidebands.)[3]
6. Double sideband can be received with either a single sideband or synchronous detection receiver. Therefore, it is compatible with single sideband. The synchronous receiver eases transmitter stability requirements by phase locking to the double sideband signal[1].

CIRCUIT DETAILS

In a double sideband transmitter, the modulation process occurs in an amplifier using two tetrode or pentode tubes, called a balanced modulator. Recently published double sideband modulator circuits—a typical diagram is shown in Fig. 1—have shown the RF driving signal applied to the control grids in push-pull; and the audio modulating signal to the screen grids in push-pull. The tube plates are then connected in parallel to cancel out the RF carrier. This circuit is particularly suited to high power balanced modulators, since an expensive high voltage split-stator variable capacitor is not required in the plate circuit.

Examination of the schematic diagram for the DOUBLE SIDEBAND JUNIOR transmitter, Fig. 2, will reveal that the RF output stage consists of two Type 6AQ5 pentode tubes (V_2 and V_3) with the control grids in parallel, and the screen grids and plates in push-pull. This balanced modulator circuit was chosen because a compact receiving type two-section variable capacitor (C_1) can be used in the push-pull plate tank circuit. The RF output is link coupled from the center of the plate tank coil (L_2).

The grids are driven by a crystal controlled oscillator, one half of a 12BH7 twin triode tube (V_{1A}). The other half (V_{1B}) is the audio modulator stage. The RF output stage is screen modulated with the push-pull audio signal, transformer coupled from the modulator stage. The transformer specified for T_2 is connected backwards (primary to the screen grids of V_2 and V_3; secondary to plate of V_{1B}). The RF carrier signal applied in parallel to the control grids of the 6AQ5 tubes is cancelled out in the push-pull plate circuit.

With no modulation the plate current in both final tubes will be low because of the low screen voltage. If a sinusoidal audio tone is assumed as the modulating

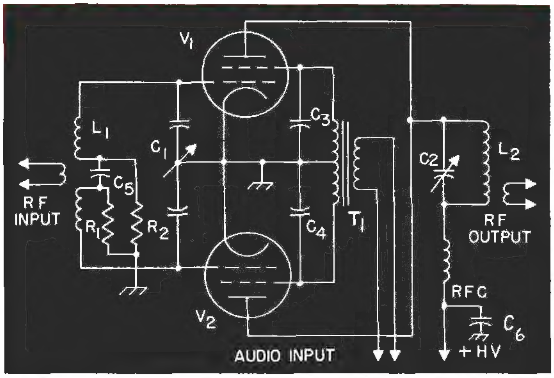


Fig. 1. Schematic diagram for the balanced modulator circuit used in most double sideband transmitter descriptions. Parts values are dependent on tube type and frequency.

signal, one screen is driven positive during the first half-cycle and the other is driven negative. The 6AQ5 having positive screen grid conducts and an RF current is supplied to the load by that tube. During the next half of the audio cycle, the other tube supplies RF power to the load and the first tube rests. Note that only one tube is working at any one time, except when there is no audio; then both tubes rest. Neutralization is no problem, as the balanced modulator circuit is self-neutralizing.

A positive bias for the 6AQ5 screen grids—about 13 volts—is developed across the 2000-ohm resistor in series with the cathode-to-chassis connection for the modulator tube (V_{1B}). Current for operating a carbon microphone is supplied through the 1500-ohm resistor.

The two audio voltage amplifier stages employ a 12AU7 twin triode (V_4). The first stage is driven by a single button carbon microphone through a matching transformer (T_3). The first audio stage drives a shunt-type diode clipper circuit which clips both positive and negative audio signal peaks. The clipping level is adjusted by varying the positive bias on the clipping diodes, D_1 and D_2. This bias is obtained from a 1000-ohm potentiometer in series with the cathode-to-chassis circuit of the second audio amplifier stage (V_{4B}).

A simple pi-section audio filter (C_2, C_3 and L_3) following the clipper suppresses the audio harmonics ("splatter") generated in the clipping process. The second audio stage then drives the modulator (V_{1B}).

Push-to-talk operation of the transmitter is obtained simply by grounding the cathode of the crystal oscillator tube (V_{1A}) through a single pole, single throw, normally open push-button switch of the type found on most single button carbon microphones (war surplus T-17, or Electro-Voice Model 210-KK). If the push-to-talk feature is not desired, substitute a two conductor phone jack for the three conductor jack (J_3) shown in the schematic diagram.

Additional audio amplification will be required if a low-output crystal, ceramic or dynamic microphone will be used with the transmitter in place of the carbon microphone. This extra gain can be obtained with a 12AX7 twin triode tube in a two-stage audio preamplifier. The circuit for this amplifier, which will deliver a voltage gain in excess of 1000, is shown in Fig. 2. The arm on the 250,000-ohm gain control at the output of the second stage (V_{6B}) feeds directly into the grid of V_{4A}. The transformer (T_5) and carbon microphone voltage circuit can thus be eliminated.

The transmitter may be constructed with the high voltage power supply shown in the main schematic

diagram; or, any separate power supply capable of delivering 400 volts at 70 ma may be used instead. A lower plate supply voltage will result in reduced RF power output from the transmitter.

Since operation of 6AQ5 tubes with 400 volts on the plates is above any specified rating, applying a sustained audio modulating tone probably would overload the tubes and make them gassy, thus ruining them.

The transmitter may be operated in mobile service with a PE-103 dynamotor as a plate power supply. The microphone control circuit should be connected to switch the dynamotor rather than the oscillator.

If operation on other bands is desired, it will be necessary to change only L_1 and L_2. L_1 should be self-resonant at the crystal frequency and L_2 should be a conventional balanced tank coil for the band in use. The transmitter may be operated on two bands, as it is possible to double in the final amplifier. For example, if an 80-meter crystal and a 40-meter tank coil (L_2) are used, the output will be in the 40-meter band. This method of operation is not highly recommended, but only mentioned as a possibility.

No special effort has been made to achieve a high order of carrier suppression. However, laboratory measurements indicated 40 db of suppression in the original model. At least 30 db of carrier suppression should be obtained with reasonably symmetrical wiring in the RF output circuit. In most cases, the audio hum and noise level will be about equal to the carrier level.

MECHANICAL DETAILS

The transmitter shown on page 1 was constructed on a 7 x 12 x 3-inch aluminum chassis (Bud AC-408). A smaller chassis, or utility box, will easily hold the RF and audio components, especially if the power supply is constructed on a separate chassis. Of course, if a suitable high voltage supply already is available, utilize it instead.

The same relative locations for major parts, as shown in the chassis drilling diagram, Fig. 3, should be followed. If the audio preamplifier for low output microphones is to be included, the tube socket should be placed in the location indicated on this diagram. The

PARTS LIST—DOUBLE SIDEBAND JUNIOR

- C_1..two-section variable, 7—100-mmf per section (Hammarlund MCD-100S or equivalent)
- C_2....500-mmf, 500-volt mica
- C_3....300-mmf, 500-volt mica
- C_4, C_5, C_6....25-mfd, 50-volt electrolytic
- C_7, C_8....40-mfd, 450-volt electrolytic
- C_9....16-mfd, 450-volt electrolytic
- D_1, D_2....1N63 germanium diodes (G-E 1N63)
- J_1, J_2....two-conductor, closed-circuit phone jack
- J_3....three-conductor, open-circuit phone jack
- L_1..15 uh, 50 turns, No. 28 enameled wire, scramble wound ¼ of an inch long on a ⅜-inch diameter iron slug-tuned coil form (CTC LS-3)
- L_2..44 uh, 48 turns, No. 22 wire, 1½ inches long, 1¼ inches in diameter, with 3-turn link at center (B&W 80JVL)
- L_3..6 henry, 40-ma, 300-ohm iron core choke (UTC R-55 or equivalent)
- L_4..14 henry, 100-ma, 450-ohm iron core choke (UTC R-19 or equivalent)
- R_1....1000-ohm, 2-watt potentiometer
- R_2....3100-ohm, 5-watt wire-wound resistor
- R_3....250,000-ohm potentiometer, audio taper
- RFC_1....2.5 mh RF choke
- S_1....single pole, single throw toggle switch
- T_1..Power transformer, 880 volts center tapped, 75 ma DC, four 6.3-volt heater windings, 115-volt, 60 cycle primary (Triad R-70A or equivalent) (6 X 4 rectifier heater should be powered from separate 6.3-volt winding on T_1.)
- T_2..driver transformer, turns ratio 5.2 to 1, primary to ½ secondary; connect primary as secondary and vice versa.) (Thordarson 20D79 or equivalent)
- T_3..line or single button carbon microphone-to-grid transformer, turns ratio 31.4 to 1. (Triad A-1X)
- V_1....12BH7A tube
- V_2, V_3..6AQ5 tube (G-E types 6005 Five-Star, or 6669 Communication series, also suitable)
- V_4....12AU7 tube
- V_5....6X4 tube (5Y3-GT if T_1 has 5-volt winding)
- V_6....12AX7 tube (optional audio amplifier)

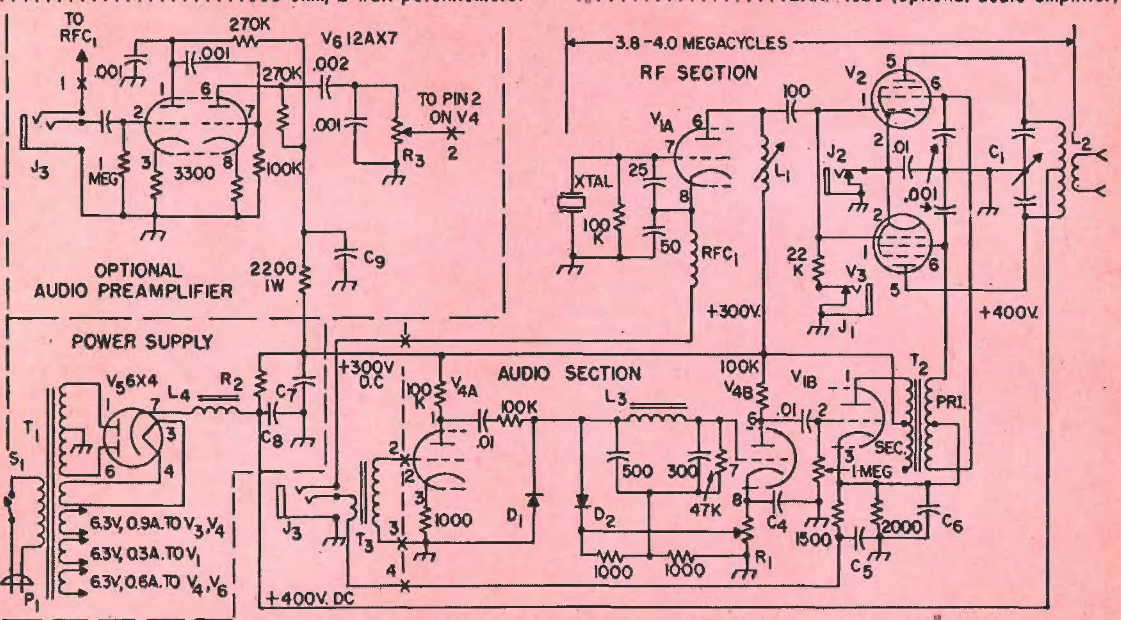
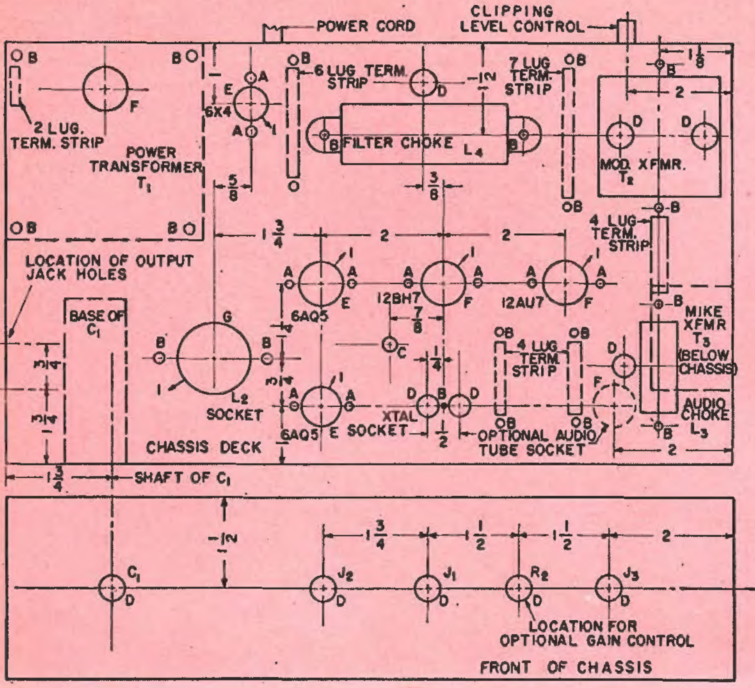


Fig. 2. Schematic diagram for the complete 20-watt double sideband transmitter. The high voltage power supply, shown within dotted lines, may be eliminated if a suitable supply already is available. The optional audio preamplifier appears in the upper left-hand corner. Capacitances given in whole numbers are mica, 500 volts working; those in decimals are disc ceramic, 500 volts working. Resistors are ½ watt unless otherwise specified.



DRILLING LEGEND

"A" drill—No. 32 for miniature tube socket hardware.
"B" drill—No. 26 for fastening terminal strips and larger components.
"C" drill—$\frac{9}{32}$ of an inch in diameter for L_1.
"D" drill—3/8 of an inch in diameter for controls, grommets, etc.
"E" socket punch—5/8 of an inch in diameter for 7-pin miniature tubes.
"F" socket punch—3/4 of an inch in diameter 9-pin miniature tubes and grommet under T_1.
"G" socket punch—1 1/4 inches in diameter for L_2.

Fig. 3. Chassis deck and front panel drilling diagram for the double sideband transmitter. Dimensions are shown from the edges of a 7 x 12 x 3-inch deep chassis. Tube sockets should be mounted with pin 1 in the position indicated at each socket hole. The socket for the optional audio preamplifier tube (V_5) and gain control (R_3) are located as shown.

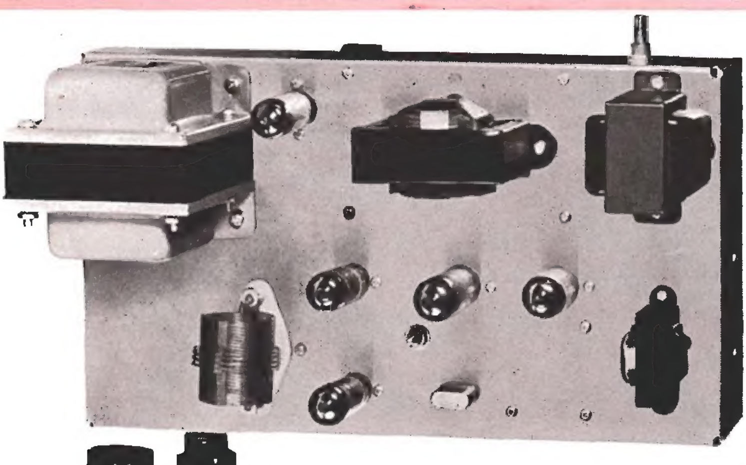


Fig. 4. Top view of the double sideband transmitter, showing the locations of major parts on chassis deck. Check to see that sufficient space is provided for components which differ in size and shape from those listed. The audio filter inductor (L_2) and the microphone transformer (T_3) should be oriented in the positions shown to prevent inductive hum pickup from the power transformer (T_1).

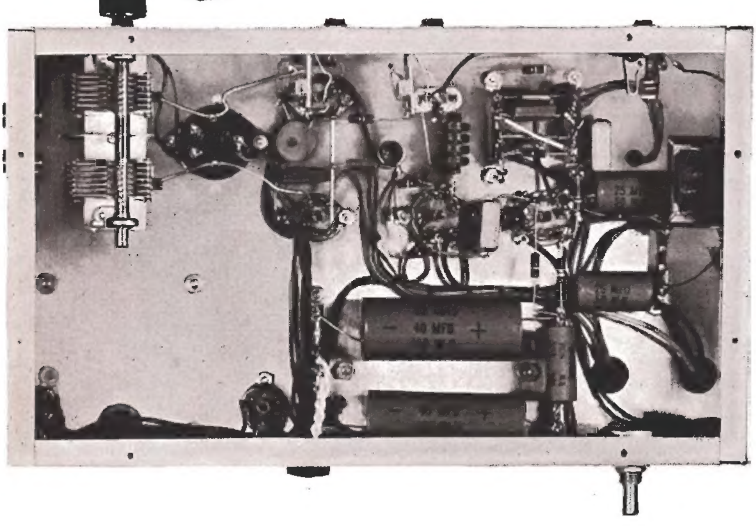


Fig. 5. Bottom view of the chassis, showing placement of smaller parts on the tube sockets and terminal strips. Power wiring is run in corners and across the center of the chassis. Wires carrying audio and RF voltages should be made as short as possible.

matching transformer for a carbon microphone, T_3, is then not required. The audio low-pass filter inductor, L_2, should be mounted beneath the chassis in place of T_3. The gain control between stages in the extra audio amplifier may be mounted midway between J_1 and J_3 on the front of the chassis, as indicated on the drawing.

Small holes for component fastening hardware should be located directly from the matching holes on each part; the drilling diagram simply indicates the presence, but not the precise location, of these holes. Rubber grommets should be placed in all chassis holes for transformer leads before these parts are assembled in the locations shown in the top view photo, Fig. 4.

The smaller parts beneath the chassis are fastened between tube socket lugs and lugs on other parts, or on lug-type terminal strips (Cinch-Jones 2000 series). Most of the audio clipper and low-pass filter components were assembled between two four-lug strips, as shown in the bottom view photo, Fig. 5. Note that the tubular type electrolytic filter and cathode bypass capacitors fit neatly into unused portions of the chassis. Use of metal can type capacitors will require crowding of some components on the chassis deck.

All power and audio circuit wiring was run with No. 20 stranded, insulated hookup wire. Heavy tinned copper wire was used for the lead between the 6AQ5 control grid socket pins; also for connecting the 6AQ5 plate lugs to the socket for L_2 and stators on C_1. Small insulated banana jacks were mounted on one end of the chassis for antenna terminals, but a suitable chassis type coaxial cable connector may be substituted.

The audio preamplifier stage, which may be added to the transmitter at any time, was constructed on a turret type 9-pin miniature socket (Vector No. 8-N-9T), as shown in the photo of Fig. 6. There is adequate room on this socket for all small parts, but the 16-mfd, 450-volt filter capacitor in the plate voltage decoupling filter should be placed in the corner behind T_3.

ADJUSTMENT AND OPERATION

Once the transmitter has been completed, it should be tested on a dummy load consisting of a 15- or 25-watt, 115-volt incandescent lamp bulb. The test procedure consists of the following steps:

1. Apply power and insert a crystal for the 3.8–4.0-megacycle phone band. Depress the microphone push-to-talk switch.
2. Adjust L_1 to resonance while observing the final amplifier grid current on a milliammeter inserted at J_1. A grid current of 3 to 4 milliamperes is required for proper operation.
3. Set R_1 to its midpoint. Adjust L_2 for closest coupling. Whistle into the microphone and adjust C_1 for maximum output power or maximum brilliance of the dummy load lamp.
4. Observe the RF output voltage with an oscilloscope. Either the bowtie or envelope presentation may be used[5]. Whistle into the microphone. Successively adjust the output coupling and clipping level (R_1) for maximum output voltage consistent with ***linearity***[6].
5. Upon successful completion of testing with a dummy load, the transmitter may be connected to a transmitting antenna. The antenna should preferably be a low impedance tuned antenna, such as a dipole or folded dipole. If a long wire antenna is used, an antenna tuner should be used to transform the antenna impedance down to a value suitable for link coupling. When the transmitter is connected to the antenna, step 4 should be repeated to ensure that the output stage is properly adjusted and not overloading on positive audio peaks. The final amplifier cathode current may be metered at J_2. The plate current will have a resting value of about 20 ma and will rise to about 40 ma with modulation.

Although the basic transmitter is crystal controlled, the output of a variable frequency oscillator may be fed into the crystal socket with a short length of 300-ohm twinlead. It is important that this external oscillator have an isolating stage between it and V_{1A} to prevent frequency modulation of the signal. The VFO also should have good long-term frequency stability. Otherwise, the other participants in a round-table QSO will keep reminding you to get back on frequency.

DOUBLE SIDEBAND JUNIOR has sufficient RF output to drive a pentode linear amplifier in the one-kilowatt power class; or a triode linear amplifier in the 400-watt class, such as the LAZY LINEAR (See *G-E HAM NEWS*, July-August, 1949, Vol. 4, No. 4, for details). But even when operated "barefooted," it should have a normal working range of several hundred miles on the 3.8-megacycle band.

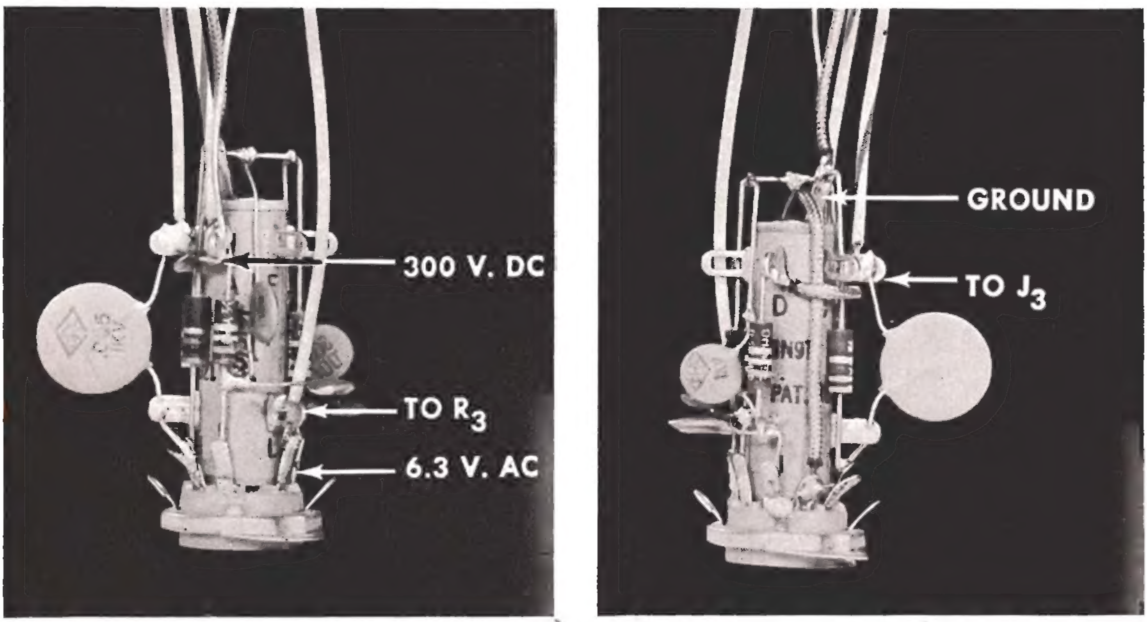


Fig. 6. Detail views of the audio preamplifier stage constructed on a turret type 9-pin miniature tube socket (Vector No. 8-N-9T). Terminals to which external connections are made have been labeled.

EDISON RADIO AMATEUR AWARD
1957 WINNER
James E. Harrington, K5BQT

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HEROIC TRIO (UPPER RIGHT)—James E. Harrington (center), K5BQT, winner of General Electric's 1957 Edison Radio Amateur Award, is shown with his two companions re-enacting their mission of mercy down the Calcasieu River on a fishing boat last June after Hurricane Audrey. With Sgt. Michael J. McDermott (left), K5CTQ, and Capt. Neal Mabrey, W5VTU—both of the Lake Charles Air Force Base—Harrington unloaded heavy radio gear (CENTER, RIGHT) through flood waters, set up and operated for three days at devastated Cameron, La. More than 1500 emergency messages were handled in the disaster which took more than 500 lives.

At home, K5BQT proudly displays his new call-letter license plate to Mrs. Mae Harrington (CENTER, LEFT); and operates his home station (BOTTOM) while son Bill, 11, looks on.

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I NEED YOUR HELP!

Since amateur radio is a rapidly growing and continuously changing hobby, I would like to know more about your current interests. Please take a minute or two to read the questions below and mark your answers on the coupon at the bottom of this page. Then clip the coupon, and return address above it, paste them securely on a postal card, and mail it to me.

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—Lighthouse Larry

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Manufactured	☐	☐	☐	☐

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7. Yes ☐ No ☐ Other________

8. ________

9. ________

Sweeping the Spectrum

MEET THE DESIGNER—John K. Webb, K2GZT, took a busman's holiday from his profession as electrical design engineer on synchronous and other communications systems at our Light Military Electronic Equipment Department in Utica, New York. Result—the DOUBLE SIDEBAND JUNIOR transmitter in this issue!

Some measure of Jack's enthusiasm for double sideband can be garnered from his many presentations on this subject at trade shows, amateur radio conventions, hamfests, and club meetings. Of course, this little transmitter usually accompanies him as his favorite "conversation piece."

First licensed as WϕAHM in Kansas during 1947, Jack's association with electronics includes AM broadcasting and the U.S. Army Signal Corps, before joining General Electric. Although he has tried 'em all—CW, FM, AM and SSB—Jack can now be found on 14-megacycle phone pushing a pair of GL-6146's in a—you guessed it—double sideband rig!

* * *

When the judges for the 1957 Edison Award met late in January, they not only chose K5BQT as the principal winner, but drafted a public service commendation to be awarded to the following officially nominated candidates for the 1957 award:

W1MCL, W2FGV, W2IIN, W2RUF, K2KGJ, K2-KMV, W3ECP, W3UVK, W4DRC, W4FUS, W4-HUL, W4NTO, W4RRH, W4SBI, W4SDR, K4KCV, W5KRJ, W5LZW, W5SUB, W5SYL, W5TIE, W5-UCT, W6AAQ/1, W7BA, W7GNJ, W7IOQ, W7OEX, W8BUQ, W8CTZ, W8FAZ, W8IMH, W8YWU, W8-YGQ, W9BUK, W9VEY, WϕBDR, WϕCPI, WϕDSP, WϕKCK, WϕLF, WϕWMA, KϕAFW, KϕEDF; and a posthumous commendation to W8HSG.

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G-E HAM NEWS

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Printed in U.S.A.

VOL. 13—NO. 2

published bi-monthly by
ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.
In Canada
CANADIAN GENERAL ELECTRIC CO., LTD.
189 Dufferin St., Toronto 3, Ontario

E. A. NEAL, W2JZK—EDITOR

MARCH-APRIL, 1958

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